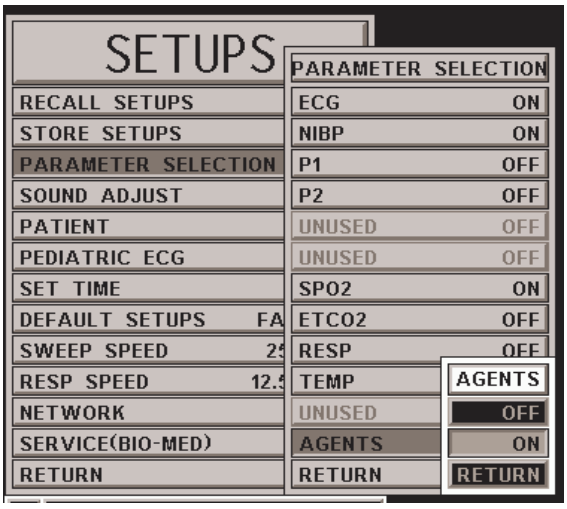
2	Ensure that a working galvanic oxygen sensor is installed in the unit. If the oxygen sensor is missing or malfunctioning, the error message AGENT HW FAIL - O2 SENSOR will appear near the top of the display shortly after activation of the agents vital sign. Should this happen, replace the oxygen sensor as instructed in *Oxygen Sensor Replacement.*
3	Allow the AGS to run and sample room air for at least one minute. The O_2 reading should be 21%. If the reading remains outside this range for more than one minute after first checking the reading, replace the oxygen sensor as instructed in *Oxygen Sensor Replacement.*
4	After allowing the AGS to run for at least one minute, pinch or seal off the input line for five seconds and verify that the message CO2 OCCLUSION appears on the display. If this message does not appear, check all tubing connections for leakage and retest.

Agents Vital Sign Activation

To activate the anesthetic agents vital sign, do the following:

Step	Action
1	Press the MONITOR SETUP on the DCU keypad.
2	Select the Parameter Selection on the Setups menu.
3	Select the Agents on the Parameter Selection menu.
4	Select On from the Agents option list.

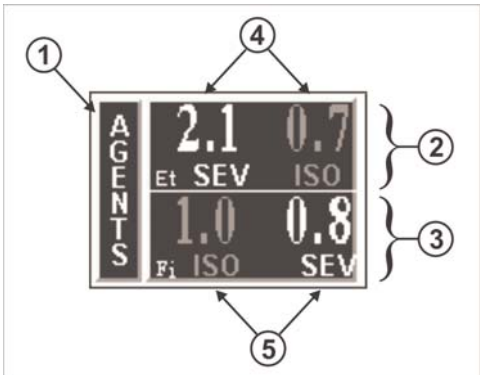
This sequence is shown below:



When the agents vital sign is activated, the Agents and Gas vital sign boxes will appear near the bottom of the display. The CO_2 vital sign box will also be activated on the right side of the display, if it was not already displayed.

Agents Vital Sign Display

The anesthetic agents vital sign information is displayed in the Agents vital sign box as shown in the figure below. The agent data is displayed as numeric values only. The following paragraphs explain the numbered elements in the AGENTS vital sign box.



Agents Box Elements

1. The Agents vital sign box label identifies the box as containing the anesthetic agents vital sign information.

2. The top half of the Agents box contains the concentrations and gas identifications of the anesthetic gas(es) detected in the expired Et breath phase.

3. The bottom half of the Agents box contains the concentrations and gas identifications of the anesthetic gas(es) detected in the inspired Fi breath phase.

4. The numeric values in the Agents box indicate the concentrations of each detected agent gas in volume %, rounded to the nearest 0.1 volume %.

5. These text strings are abbreviations for the specific identified agents gas(es) detected, as follows:

- DES – Desflurane
- ENF – Enflurane
- HAL – Halothane
- ISO – Isoflurane
- SEV – Sevoflurane

Note—If questionable anesthetic agent gas measurements are observed, recheck patient connections, anesthesia gas machine and/or vaporizer before re-adjusting anesthesia delivery.

"No Data Available" Indication ("---")

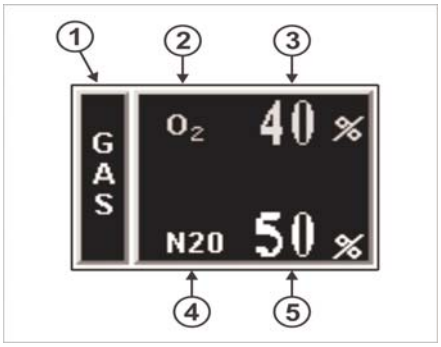
Under certain conditions, one or more numeric values in the Agents box may be displayed as a series of 3 dashes ("---"). This means that there is currently no data available for the item or items. This can happen for any of the following reasons:

- There is currently no communication with the Cart/PMC Mount.
- The agent gas monitoring hardware is warming up.
- The concentration of anesthetic agent is below the minimum volume percent that is detectable by the system.

Note—No gas reading is denoted by a white "X" in the agent identification and "---" in the agent values. With no gas reading when agent vaporizer is first turned on, it may take 30 seconds to 1.5 minutes for agent identification and reading to be displayed. Once identification is established, changes in concentration are virtually immediate. With a 200% change in concentration, an auto zero will occur, and full accuracy of the changed concentration will be accomplished within approximately 30 seconds.

O_2/N_2O Vital Sign Display

The AGS system also monitors the concentrations of O_2 and N_2O. This vital sign information is displayed in the Gas vital sign box as shown in the figure below. The following paragraphs explain the numbered elements in this box.



GAS Box Elements

1. The Gas vital sign box label identifies the box as containing the O_2 and N_2O agents vital sign information.
2. The O_2 label identifies the value to the right as the oxygen concentration value.
3. The oxygen concentration in percent is the detected average of Fi and Et.
4. N_2O identifies the value to the right as the nitrous oxide concentration value.
5. The nitrous oxide concentration in percent is the detected average of Fi and Et.

"No Data Available" Indication ("---")

Under certain conditions, one or more numeric values in the Gas box may be displayed as a series of 3 dashes ("---"). This means that there is currently no data available for the item or items. This can happen for any of the following reasons:

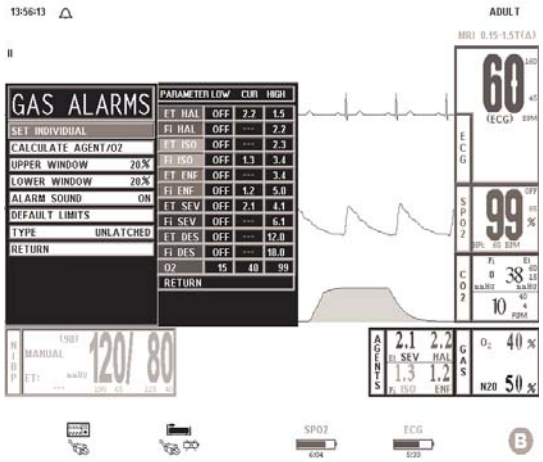
- There is currently no communication with the Cart/PMC Mount.
- The agent gas monitoring hardware is warming up.
- The concentration of O_2 or N_2O is below the volume percent that is detectable by the system.

Gas Alarms Menu

The Gas Alarms menu shown in the figure below permits setting and adjusting the low and high alarm limit values for each anesthetic agent gas and O_2.

This menu can be activated in 2 ways:

- Press ALARMS on the DCU keypad, then select the Gas Alarms item located on the Alarms menu, or
- Rotate the knob so that the Agents vital sign box is highlighted, then press ALARMS on the DCU keypad.



Note—Some hydrocarbons (e.g. acetone and methane) will cause a mixed agent alarm to occur.

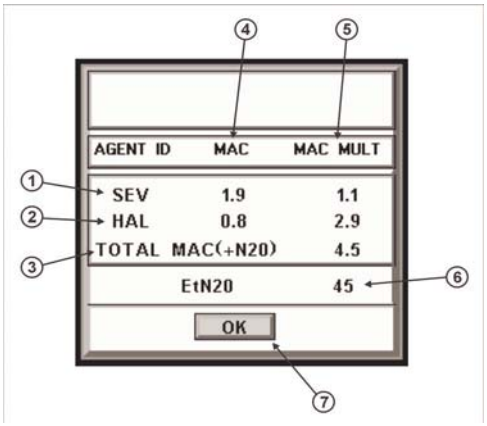
MAC Window

The Minimum Alveolar Concentration (MAC) window, shown in the following figure, displays the current MAC values for the primary and secondary gases that are currently being detected.

To activate the MAC window, rotate the knob until the Agents vital sign box is highlighted, then press the knob. To close the MAC window, press the knob again.

Warning

Minimum alveolar concentration (MAC) values are empirical and are not absolute values. The Invivo MAC values correspond to those of healthy adults and cannot be applied to children. Age and other individual factors influencing the behavior of volatile agents are not taken into account.



MAC Window Elements

1. The gas ID, current MAC value, and MAC multiplier for the currently detected primary agent gas.
2. The gas ID, current MAC value, and MAC multiplier for the currently detected secondary agent gas.
3. The total MAC value of the primary and secondary gases and N_2O currently detected by the system.
4. The MAC column displays the MAC value for the primary and secondary agents.
5. The MAC Multiplier column displays the multiplier for the corresponding agent value. MAC multiplier is defined as the percent concentration of the Agent divided by the MAC value for this agent.
6. The nitrous oxide concentration in percent is the detected N_2O in the expired breath phase.
7. Selecting OK returns the display to the normal screen.

MAC Calculation *Note*—MAC window values are only valid when no more than 2 Agents are present.

The 1 MAC values used for each agent gas are given in the table below:

Gas	1 MAC Value
DES (Desflurane)	6.00 volume %
ENF (Enflurane)	1.68 volume %
HAL (Halothane)	0.76 volume %
ISO (Isoflurane)	1.12 volume %
SEV (Sevoflurane)	1.92 volume %
N2O (nitrous oxide)	100%

The total MAC value is calculated using the following formula:

Total MAC = EtN_2O / (1 MAC N_2O) +

(Et 1^{st} Agt) / (1 MAC 1^{st} Agt) +

(Et 2^{nd} Agt) / (2 MAC 2^{nd} Agt)

Where:

- EtN_2O = The current value of expired nitrous oxide
- 1 MAC N_2O = The 1 MAC value for nitrous oxide
- Et 1^{st} Agt = The current concentration of the primary agent gas
- Et 2^{nd} Agt = The current concentration of the secondary agent gas
- 1 MAC 1^{st} Agt = The 1 MAC value for current primary agent gas
- MAC 2^{nd} Agt = The 2 MAC value for current secondary agent gas

Agents/Gas Operation and Use

These paragraphs cover typical conditions that will arise, as well as possible error conditions that could occur during anesthetic agents monitoring.

Warning

Organic vapors (e.g. from cleaning agents) in the sampling line or room air may alter anesthetic agent readings.

Warning

Alcohol in the patient's breath may modify the anesthetic agent readings.

Warm-Up Period

The AGS requires a warm-up period to thermally stabilize to achieve accurate gas identification and measurement. The warm-up period begins when the AGENTS or CO_2 vital sign is activated. Once this happens, the AGS will become fully operational according to the following sequence:

1. During the warm-up period, the message ETCO2 WARMING UP will be shown near the top of the DCU display in flashing red and white text.
2. Within 45 seconds of activation, the AGS will be able to identify gases and give gas concentrations with ISO-level accuracy. Until then, the vital sign numeric values in the AGENTS, GAS, and CO_2 vital sign boxes will be displayed in the "no data available" state ("---").
3. Within 10 minutes of activation, the AGS will be able to operate at full accuracy.

Zero Reference Adjustment

The AGS will occasionally perform a ***zero reference adjustment***, meaning that it will briefly interrupt gas monitoring to take in room air through the system's reference gas port (the "zero port"). This zeroing is done to ensure that the displayed gas concentrations are accurate.

Whenever a zero reference adjustment is being performed, the message READJUSTING CO2 ZERO will be shown near the top of the display in flashing red and white text.

Zero reference adjustments typically take 10 to 12 seconds each and will occur automatically as needed by the system. Most of these zeroing adjustments occur during the warm-up period. Once the AGS has become fully operational (within 10 minutes), zero reference adjustments will occur approximately once every four hours, or whenever the AGS temperature changes by at least ±1°C from the last stored stable temperature.

Note—Whenever the *Expression* MRI Patient Monitoring System agent sensor changes from steady state condition, the *Expression* will perform an auto zero to restabilize the sensor readings. During this time it is possible for a false identification and concentration value to occur. A change from steady state condition may occur as a result of any of the following scenarios:

- Applying sample line for the first time.
- Switching from one agent to another.
- Going from high agent concentrations to low or off.

Note—During the first hour following power on and flowing oxygen greater than 50%, the CO_2 waveform periodically baselines to complete reference measurement, however, numeric values remain. Once the system reaches ambient temperature this condition will cease to occur.

A zero reference adjustment can also be completed manually as follows:

Step	Action
1	Rotate the knob until the CO_2 vital sign box is highlighted, then push the knob to display the **C**O_2 menu.
2	Select the GAS CAL item on the on the CO_2 menu.
3	Select the ZERO CAL item on the GAS CAL menu.

Multiple (Mixed) Agents

Multiple agents condition exists whenever two or more anesthetic agent gases of detectable concentrations are detected by the AGS in the agents pneumatic circuit. A multiple agent condition is also considered to exist even when the agent gases in the inspired and expired breath phases are pure but different from one another.

Whenever a multiple agent condition exists, the message MULTIPLE AGENTS will be shown near the top of the display in flashing red and white text.

It is common for multiple agent conditions to occur during the transition from one anesthetic agent to another, such as when one agent is used to induce a patient and another agent is used to maintain the sedated state.

Low Flow and Occlusion Conditions

A ***low flow*** condition exists whenever the gas flow falls to 10% less than the nominal flow for the currently selected patient type as shown in the following table:

Patient Type	Sample Flow Rate	Flow Rate When Low Flow Declared

Neonate	150 ml/min	≤ 135 ml/min
Pediatric	200 ml/min	≤ 180 ml/min
Adult	200 ml/min	≤ 180 ml/min

Whenever a low flow condition exists, CO2: LOW FLOW will be shown near the top of the display in flashing red and white text. The alarm tone will also sound.

An *occlusion* condition exists when AGS hardware has detected that the gas flow has fallen below 40 ml/min for at least 1 second.

Whenever an occlusion condition exists, CO2 OCCLUSION will be shown near the top of the display in flashing red and white text. The alarm tone will also sound.

The usual cause of these conditions is a pinched sample line or a sample line that contains a blockage (usually from excessive moisture from patient expiration).

Strong Magnetic Field

If the Cart or PMC Mount containing the AGS is powered up or moved too close to the MR system bore, the message "Unable to monitor patient airway gases, temporarily move WPU away from magnet" will appear on the display. If this happens, move the Cart or PMC Mount away from the MR system until the error message disappears.

Hardware Failure

In the event that the AGS hardware experiences a problem or failure that would prevent proper operation of unit, the following occurs:

- ETCO2 HW FAIL is displayed near the top of the display in flashing red and white text.
- The alarm tone sounds.
- The vital sign numeric values in the AGENTS, GAS, and CO2 vital sign boxes are displayed in the "no data available" state ("---").

Oxygen Sensor Depletion

The oxygen sensor used in the *Expression* uses galvanic technology. The oxygen sensor has a life of 12 months from the date of manufacture. Therefore, users should note the manufacture date (printed on the oxygen sensor can) before installing the sensor and plan accordingly for when the sensor should be replaced. If the O_2 sensor reaches the point where replacement is necessary, the message "TURN OFF CO2, REPLACE O2 SENSOR" is shown near the top of the display. Replace the sensor as described in *Oxygen Sensor Replacement.*

Oxygen Sensor Replacement

The oxygen (O_2) sensor (Part Number 989803162051) is located at the rear of the Cart as shown in the following figures:

The oxygen (O_2) sensor (Part Number 989803162051) is located at the rear of the PMC Mount as shown in the following figure:

Perform the following steps to replace the oxygen sensor:

Step	Action
1	Turn off the CO_2 vital sign parameter.
2	Replace the oxygen sensor located at the rear of the Cart or PMC Mount by using the O_2 sensor installation tool (Part Number 989803162961) attached to the oxygen sensor port as shown in the preceding figure. a. Place the tool into the sensor slot and turn counterclockwise until sensor is disengaged. b. Place the new sensor into the threaded port and place the tool into the sensor slot and turn clockwise until sensor fits securely into port.
3	Assure that a gas sampling line is connected to the water trap. The gas sampling line must not be connected to the patient or any other gas source during oxygen sensor replacement.

Step	Action
4	Turn on the Agents parameter and allow the system to run until the message ETCO2 WARMING UP is no longer displayed near at the top of the DCU screen.
5	Initiate an O_2 pressure calibration by performing the following steps: a. Press MONITOR SETUP on the DCU keypad. b. Rotate the knob to highlight the SERVICE (BIO-MED) menu item, then press the knob to select this item. c. Select the GAS CAL menu item. d. Select the O2 CAL menu item. A dialog will be displayed that reads: FLOW ROOM AIR FOR 10 SECONDS, Do you wish to continue? e. Rotate the knob to highlight YES (it should already be highlighted by default) and press the knob to select this choice. The message READJUSTING CO2 ZERO will be shown near the top of the display. When this message disappears, O_2 pressure calibration is complete.

Warning

The gas sampling line must not be connected to the patient airway adapter or any other gas source during oxygen sensor replacement, as it will cause an incorrect calibration or O_2 reading.

Note—In order to ensure the stability of the oxygen sensor, the manufacturer recommends waiting at least one hour to use the oxygen sensor after opening the packaging.

Note—Recommendation: To avoid waiting one hour after opening the packaging, remove the oxygen sensor from the packaging as soon as received or prior to beginning monitoring. Always make note of the manufacture date of the oxygen sensor (printed on the can). The oxygen sensor has a life of 12 months from the date of manufacture.

Warning

CO_2 and anesthetic agent calibration cylinders and test gas mixtures must be completely drained of pressure before disposal. CO_2 and anesthetic agent calibration cylinders and test gas mixtures must be completely drained of pressure before disposal. Contents are under pressure and may cause hazard if container is punctured.

Agents Messages

The following table lists messages that may be displayed by the system during anesthetic agents monitoring. The meaning, probable cause, and recommended action is also provided. These messages appear at the top of the DCU screen in the informational display area.

Message	Probable Cause	Recommended Action
MAGNETIC FIELD TOO HIGH	The system is too close to the MR system room and agents operation is impacted.	Move the *Expression* MRI Patient Monitoring System away from the magnetic field. If the condition remains contact Invivo Technical Support or Invivo-authorized service personnel.
CO2 OCCLUSION	1) The message "CO_2 OCCLUSION" will be displayed when a sample line occlusion is detected and flow is <40 ml/min. 2) The water trap may be full of fluid.	1) Check the Patient Sampling Line for any bends, kinks or debris. If any are observed, replace the Patient Sampling Line. 2) Replace the water trap. If the condition remains contact Invivo Technical Support or Invivo-authorized service personnel.
ETCO2: HW FAIL	The system $ETCO_2$/Agents hardware has failed.	Discontinue use of the $ETCO_2$/ Agents monitoring option and contact Invivo Technical Support or Invivo-authorized service personnel.
ETCO2: LOW FLOW	1) Sampling line flow is reduced 10% from nominal. 2) This message may appear when sampling line is first connected.	Checks the Patient Sampling Line for any bends, kinks or debris. If any are observed, replace the Patient Sampling Line. If the condition remains contact Invivo Technical Support or Invivo-authorized service personnel.
TURN OFF CO2, REPLACE O2 SENSOR	The O_2 sensor has expired.	Replace the O_2 sensor.
AGENT HW FAIL – O2 SENSOR	A hardware failure associated with the O_2 sensor has occurred.	The message" "AGENT HW FAIL - O_2 SENSOR" is displayed if the operational software detects that the O_2 sensor has been physically removed from the system. Check to see if the Agent O_2 Sensor has become loose or dislodged. If so, tighten with the O_2 Sensor tool that is provided and attached to the O_2 mounting hardware. If the condition remains, contact Invivo Technical Support or Invivo-authorized service personnel.
AGENT MOTOR SPEED ERROR	A problem is detected in the agents hardware.	Discontinue use of the agents monitoring option and contact Invivo Technical Support.

Message	Probable Cause	Recommended Action
OCCLUSION WHILE ZEROING: ATTEMPTING TO RESTART	A sample line occlusion is detected by the system at start up.	1) Check the Patient Sampling Line for any bends, kinks or debris. If any are observed replace the Patient Sampling Line. 2) Replace the water trap. If the condition remains contact Invivo Technical Support or Invivo-authorized service personnel.
READJUSTING CO2 ZERO	Agent hardware is performing an automatic Zero adjustment	No Action Needed
ETCO2 WARMING UP	The message "$ETCO_2$ WARMING UP" is displayed until the agent bench is ready for use. During that time agent readings will not be displayed.	No Action Needed
MULTIPLE AGENTS	In the event of a mixed agent condition, the message "MULTIPLE AGENTS" will be displayed. No audible alarm will be provided for mixed agents.	No Action Needed
UNABLE TO MONITOR PATIENT AIRWAY GASES, TEMPORARILY MOVE WPU AWAY FROM MAGNET	In the event the agents bench is unable to start properly due to the presence of a high magnetic field, a dialog shall be displayed at the DCU informing the user of this event.	Move the *Expression* MRI Patient Monitoring System away from the magnetic field. If the condition remains contact Invivo Technical Support or Invivo-authorized service personnel.

Invasive Pressure Monitoring

The *Expression* MRI Patient Monitoring System provides up to two invasive pressure channels, P1 and P2. Most invasive pressure monitoring functions are contained in two primary menus: P1 and P2 (if the operator has selected labels for these, the menu name will be the selected label). These menus are brought up by selecting the corresponding menu-select icons.

There are three secondary menus (Printer, Alarms and Trend) associated with invasive pressure monitoring:

- **Print menu.** Used to select all printer functions and to set the printer and trace speed.
- **Alarms menu.** Used to set and/or disable the pressure alarms. The range of alarm limits for the pressure channels is -10 to 249 mmHg.
- **Invasive Pressure Trend Menu.** Used to setup and print trended information.

Caution

Reference the instructions included with the invasive pressure transducer kit.

Invasive Pressure Transducer Preparation

This system is designed for compatibility with standard pressure transducers having a 5µV/V mmHg sensitivity. The transducer cable connection is a six pin connector. Perform the following to use the Pressure Transducer:

Warning

Never place the pressure transducer(s) within the MR bore. Transducer failure, inaccurate readings or noisy MRI images can result.

Warning

Invasive blood pressure transducers are sensitive to vibrations that can occur during MRI scanning, which can lead to pressure reading inaccuracies. Always mount the invasive blood pressure transducer away from areas where vibration is likely to occur.

Note—If the transducer will not zero and an error condition occurs, check that the transducer is being used as described in the Invasive Pressure Transducer Kit instructions. Select the RETRY button (on the monitor display screen) to attempt to zero the transducer again. If the transducer still does not zero, try another transducer and/or cable. If condition still does not clear, contact Invivo Technical Support or Invivo-authorized service personnel.

Warning

The fluid within the pressure transducer system is a conductive connection to the patient, and must not contact other conductive parts, including earth ground.

Note—Use only approved pressure transducers and cables, as listed in the Accessory chapter. Follow the safe use instructions that are supplied with the pressure transducer.

Step	Action
1	Insert the transducer connector cable into the appropriate Invasive Pressure Connector (P1 and P2) on the PCU front panel.
2	Connect the patient end of the pressure transducer according to the transducer manufacturer's instructions.
3	Vent the transducer to atmospheric pressure as detailed in the Pressure Monitoring Kit manufacturer’s instructions.
4	Press the **ZERO ALL** control key.
5	After successful Zeroing, close the transducer's stopcock as described in the kit instructions.